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An Analysis of Swine Progeny Records

Feeding and Carcass Data of Hogs Tested by the Dominion Experimental Farms under the Canadian Advanced Registry Policy for Swine

J. G. STOTHART
DIVISION OF ANIMAL HUSBANDRY
CENTRAL EXPERIMENTAL FARM

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J. G. STOTHART[2]

I. INTRODUCTION

The improvement of the relative capacity of animals to produce and reproduce has been the consistent objective of the live stock breeder. Although the show-ring has undoubtedly contributed its part in setting standards of type and insuring a continuity of the desired confirmation, it remained for the development of progeny testing and selecting on the basis of production to provide a sound and additive foundation for economic improvement.

Progeny tests have been a part of the program of swine improvement in most of the swine raising countries. Marked progress has been made through their use, but many workers have noted wide variations in productive ability. Taussig (27) intimates that the wide range of efficiency in the records reported indicates that there exist great possibilities of improving the performance of pigs.

The specific objects of this study were to examine the sources of such variations as may exist in the records collected in connection with the Canadian Advanced Registry Policy for Swine, and to investigate the relationships between the various production and carcass data recorded.

Before proceeding with the main problem, it might be well to review the history of pig recording or testing in other countries and trace its development in Canada.

A. THE HISTORY AND DEVELOPMENT OF PIG TESTING

The geographic features of a country, the type of pigs raised, and the market for which the finished product is intended, are the chief factors which exert an influence in the choice of a plan of performance testing of swine. The four divisions in which improvement is usually attempted are: the reproductive capacity of the sows; the rate of maturity of the offspring; their feeding efficiency; and, the quality of the carcasses produced. The plans of certain countries have considered all four of these, and others only two or three. The reproductive capacity, or fecundity, of the sows and boars is of primary importance because it is essential that the average number of pigs weaned be consistently high. Most plans consider seven pigs weaned from gilts and eight from mature sows as the minimum requirement. The rate of maturity is an indication of economy of production. The ability to produce offspring which are economical feeders is important, and, with the quality of the carcass, determines the actual profit realized.

In following the history of pig testing it will be well to keep in mind that Denmark was not only far in advance of other countries in testing this class of stock, but that most other schemes have been adopted and modelled after the original started in that country. In comparison, many other plans might be considered to be, as yet, only in the experimental stage.

[1] Adapted from a thesis submitted to the Faculty of Graduate Studies and Research of McGill University in partial fulfilment of the requirements for the degree of Master of Science, May, 1936.

[2] Graduate Assistant, Division of Animal Husbandry, Central Experimental Farm, Ottawa, Canada.

A distinction should be noted between the terms "recording" and "testing." In discussing the measuring of the production of swine in general, these terms have frequently been used interchangeably. Hereinafter, "recording" will be used to refer to schemes which collect data on the relative productive capacity of swine but do not involve the station testing of the pigs. "Testing" will apply to plans which, in addition to accumulating records on production, involve supervised testing stations.

1. In Countries other than Canada

(*a*) *Denmark.*—Pig recording originated in Denmark and was conducted on a small scale as early as 1896. By 1907, several "breeding centres" had been established on farms with well-developed pedigreed herds of swine. These were subsidized and supervised. A number of stipulations relating to efficiency of management and type of pigs in the herd had to be fulfilled before a farm could be selected as a breeding centre. At first, the work of these centres was to keep detailed records of fecundity in order to stimulate breeding efficiency. In 1907, the first testing station was founded to supplement information on breeding capacity by providing accurate data on the fattening ability and carcass quality of the hogs. A second station was established in 1909, and by 1934, five stations were testing the pigs from the nine districts into which the country is divided for live stock administration purposes.

In addition to their original work of accumulating the records on fecundity, breeding centres now systematically test the progeny of their sows at the feeding stations and produce most of the breeding stock for the country. When a sow has been nominated for testing, the breeding and farrowing data on her litter are recorded at the centre where she is located, and at eight or nine weeks of age, four pigs of the litter, two of each sex, are delivered to the testing station. These are developed to market weight under standardized conditions of management and feeding. The feed consumption per unit gain in live weight is given particular attention. A table showing the litters which required less than the equivalent of 3·30 pounds of feed for one pound live weight gain is published annually. A system of points is used in estimating the relative value of the carcasses. The complete program has many advantages, and by selection the Danish breeders have materially improved the productive capacity and value of their pigs. In particular, they have improved their native breed, the Landrace.

The requirements of the English bacon market were given special consideration by the Danes in making up their bacon standards. That they have achieved progress in the production of quality bacon is evidenced by the success of the Danish product on the British market.

(*b*) *Sweden.*—Sweden began performance testing of swine in 1923, when a testing station was established at Astorp. The plan adopted, for the most part, was similar to that followed in Denmark. In addition, and no doubt due to the inability of testing stations to adequately serve a large number of swine, Swedish pig breeders developed a plan of litter recording. This scheme had its origin in Malmöhus in 1923. It measures, in particular, the fecundity and mothering ability of the sow. Pig recording societies were instituted in various sections and the local milk recorder made responsible for counting and identifying the pigs at birth, and also for recording and weighing the number alive at three weeks of age. From these records, the mothering ability of the sow is determined, the total litter and individual pig weights at this age being taken as an index of this capacity.

Certain of the Swedish Experiment Stations which undertook performance tests have also studied the value of boars and their importance in transmitting desirable characteristics.

In a report on pig testing and litter recording in Sweden, Larsson (19) stated: "The statistics gathered as a result of the tests carried out at Astorp since 1923 have proved of inestimable value in many directions, one of the most important being the selection of pigs of a type calculated to produce the best bacon."

(*c*) *Germany.*—Litter recording was adopted in Germany about the same time as in Sweden, and it might be said to have developed to a greater extent than in any other country. Various forms of fattening trials have also been applied. In general, the breeding capacity of the sow is determined by the number and weight of the pigs at birth and at four weeks of age. Different sections of Germany started testing under separate societies, and while their organization was widely different, the final objectives had much in common. An effort is being made to nationalize the plan of testing and the lines of breeding to be followed.

One of the ultimate aims of testing in general is being realized in Germany where the production records of pigs for sale are listed with the pedigree record, and add materially to the prospective buyer's knowledge of the animal.

A German Pig Performance Book is being compiled by the National Association of Pig Breeders. Only those animals will be entered which conform to the following standards: In six litters a sow must average 10 pigs farrowed (in no single instance less than 7); an average of 9·0 and not less than 6 reared in any single litter; and, in these six litters, an average 28-day weight of 60 kilograms (132 pounds), with a minimum of 45 kilograms (99 pounds) for any single litter, must be attained; in addition, two pigs from each of three litters must fulfil the fattening centre's requirement of a daily increase in weight of 630 grams (approximately 1·4 pounds); the sow must also be healthy and of good conformation.

(*d*) *Poland.*—Pig recording was not started in Poland until 1931. The plan adopted follows the Swedish system. Only sows that meet specified litter qualifications are eligible for registration in the Polish Herd Book. In the records taken, particular attention is given to: gain in live weight per day; slaughter loss; and the distribution of fat and lean in the carcass.

(*e*) *United States.*—The problem of improving the production of swine in the United States has been undertaken in several ways, but in particular through: (*a*) Ton litter competitions; (*b*) Pork production contests; and, (*c*) Record of performance testing. The objectives in view, however, when the first two were started, were quite different to those held by other countries in endeavouring to better the bacon breeds. This no doubt was due to the wide differences in the type of hog raised as compared to the pigs developed in those countries catering to a bacon trade. There has been in recent years, a trend towards a bacon type of hog in the United States, but as yet their standards for this type are quite different to those accepted in Canada.

It was this trend to a leaner hog, and the desire for more complete information on swine breeding in general which no doubt influenced, within the last decade, the officials of some of the States in adopting systems of performance testing similar to those operating in Denmark and Sweden. In Iowa, Minnesota, Wisconsin, and at some of the Experimental sub-stations of the United States Department of Agriculture, such plans for production testing have been established. The breeding and farrowing records are kept by the breeder under the supervision of the State Experiment Stations. For the feeding test, four pigs, two males and two females, from the litters nominated to be tested are sold to the station and started on the feeding trial at 72 days of age. The pigs are fed to market weight and then the two barrows and one sow are slaugh-

tered, it being optional for the breeder to buy back the remaining sow. Each carcass is scored and retail cuts are made according to standard specifications. A value is placed on these cuts at an average Chicago price over a five-year period. In this way, the total value of the carcass is determined, and from this the carcass value per 100 pounds live weight at time of slaughter. These figures provide a ready means of comparison between carcasses of different litters. The wide variations in economy of production and value of carcass reported seem to fully justify the endeavour to standardize and improve the productive capacity of swine.

(*f*) *Great Britain.*—Great Britain has been called the "stock farm of the world." With this enviable reputation the breed societies have carefully considered the merits of various methods of improving production, developed and operating in other countries. However, due to the number of breeds supported and their individual potentialities, or for other reasons, it seems from this distance that there has been some lack of unanimity of opinion in establishing a national plan for pig testing. At the present time, only a few organizations in certain counties are carrying out schemes of recording. Plans of a larger scale have been adopted, operated for short periods, then discontinued. The chief of these have been the East Anglian Pig Recording Scheme and the Edinburgh testing station.

The East Anglian Pig Recording Scheme considered, mainly, prolificacy and rate of maturity. Certain records of carcass quality were made but not on an extensive scale. It might be noted that the index of maturity in this plan, obtained by dividing the live weight at slaughter by the number of days of age, was the foundation of the Maturity Index adopted as a requirement of the Advanced Registry Policy for Swine in Canada.

While the Edinburgh testing station is not operating at the present time, it might be well to review the plan followed during its existence. It was organized about the same time recording began in Canada, namely, 1928. The plan operated under the auspices of the Animal Breeding Research Department of the University of Edinburgh, and attempted to co-ordinate the points relative to economy of production from the breeding standpoint. The records included those of: prolificacy; economy of live weight gain combined with early maturity; and quality of carcass for the production of the best class of bacon. Four pigs conforming to the average of the litter, and selected from a litter of at least eight, were subjected to a feeding trial at the station. The degree of finish was the particular deciding factor as to the time the pigs were to be slaughtered, and the aim was to have each group marketed at about 200 pounds live weight. Slaughter records were taken on: (*a*) percentages of the parts; (*b*) carcass measurements; and, (*c*) general quality of the carcass.

Special attention in the Edinburgh testing work was directed to the economy of gains. Under this heading, out of the possible 100 points obtainable for a perfect litter in economy of live weight gain and early maturity, 80 points were devoted to economy and 20 points for rate of maturity. The maximum score for rate of gain was given for an average weekly gain of eight pounds; and under economy, 3·6 pounds of meal, or less, for one pound gain received the perfect score. In the other two sections of the test, prolificacy and quality of carcass, 100 points denoted a perfect score for each.

(*g*) *New Zealand.*—Pig recording has not been developed extensively in New Zealand. In 1928, the Waikota Pig Recording Club was started but their records have included only the number and weight of the pigs in a litter at eight weeks of age. Particular importance is given to this weaning weight. It is claimed that the average at this age is a good indication of the prospects and ultimate value of the litter.

2. In Canada—The Advanced Registry Policy for Swine

The very geographic extent of the Dominion of Canada required that careful consideration be given any national plan for pig improvement. In 1922, the Department of Agriculture inaugurated a plan of hog grading whereby a premium was paid for pigs meeting certain specifications of conformation and weight thought desirable for the production of bacon. This plan has done much to improve the type and particularly the weight limits at which hogs are marketed. These characteristics are shown by Hammond and Murray (17) to be essential for optimum and steady prices. However, after hog grading had been in operation for a few years, it became evident that a further plan embracing the breeding of the pigs was necessary to establish a broader and more permanent program of improvement.

After an extensive research into the plans of pig recording and testing in use in other countries, an experimental scheme of recording was proposed by the Joint Swine Committee investigating the problem, and was started on the Dominion Experimental Farms in 1928. The following year a few minor changes were made in the plan, which was called the Advanced Registry Policy for Swine, and its scope extended. By 1930, the policy was standardized, and since then any purebred breeder with a herd consisting of a boar and three or more sows can apply to have his sows tested for eligibility for Advanced Registration. The importance of recording is becoming increasingly evident and the policy is receiving more widespread use each year.

Station testing was not attempted at first for numerous reasons, the chief of which were: the extent of the country, which would have necessitated many stations or else shipping long distances to central stations, both of which would be costly; and the desire to first ascertain just how the policy would work in the field and what improvement would be advisable before adopting a final plan.

The first testing stations were established in 1934 at New Hamburg, Ont.; Saskatoon, Sask.; Princeville, Que.; and Charlottetown, P.E.I. This step was taken in order to obtain accurate records of feed consumption and economy of gains from different strains of pigs under standard management and feeding.

The Advanced Registry Policy is supported by the Dominion Department of Agriculture and its administration conducted by the Dominion Live Stock Branch through a chief supervisor and a staff of district inspectors. In most cases the district inspectors appointed were the hog graders already employed. An Advanced Registry Board, comprised of breeders and others connected with various branches of the swine industry, was appointed and acts in an advisory capacity to the Department of Agriculture. The testing stations operate under the Board and also have the advice and supervision of provincial committees.

At the present time, as the testing stations cannot handle all the litters to be tested, the original plan of recording is also followed. With the exception of the addition of the feed utilization record in station testing, both plans involve the collecting of complete records on prolificacy, rate of maturity, and excellence of carcasses. Minimum standards were set up under these headings as a basis of qualifying sows for advanced registration.

The procedure under the Advanced Registry Policy is as follows:—

When the entry of a breeder is accepted for recording, he is required to send the date of breeding, the name and pedigree registration number of the sire and dam of the litter to the central office 60 days before the expected date of farrowing. An inspector calls periodically at the farm, records the general conformation of the parent stock, and when the litter is between the age of four and eight weeks he tattoos and weighs the pigs. At the time of tattooing, five pigs of the litter are nominated for the slaughter test, four of which are required to be later marketed at a recognized packing plant and their carcasses scored. Five points are given each pig weaned in the litter and the sow must obtain 40

points, by weaning eight pigs, to qualify under this division of the policy, *Prolificacy*. The breeder is also required to keep accurate herd records and is assisted in so doing by the inspector.

The four pigs, of the five nominated, which are finally selected for the slaughter test are required to develop at the rate of 150 pounds cold carcass weight at 200 days of age, or the equivalent of this rate of gain. The score for maturity is obtained by dividing the actual age in days of the pig into the "standard" age for a pig of the same weight, and multiplying by one hundred. The weight-for-age curve (proposed by Duckham, 10) from which the standard age is derived is given in Chart I. The four pigs must have

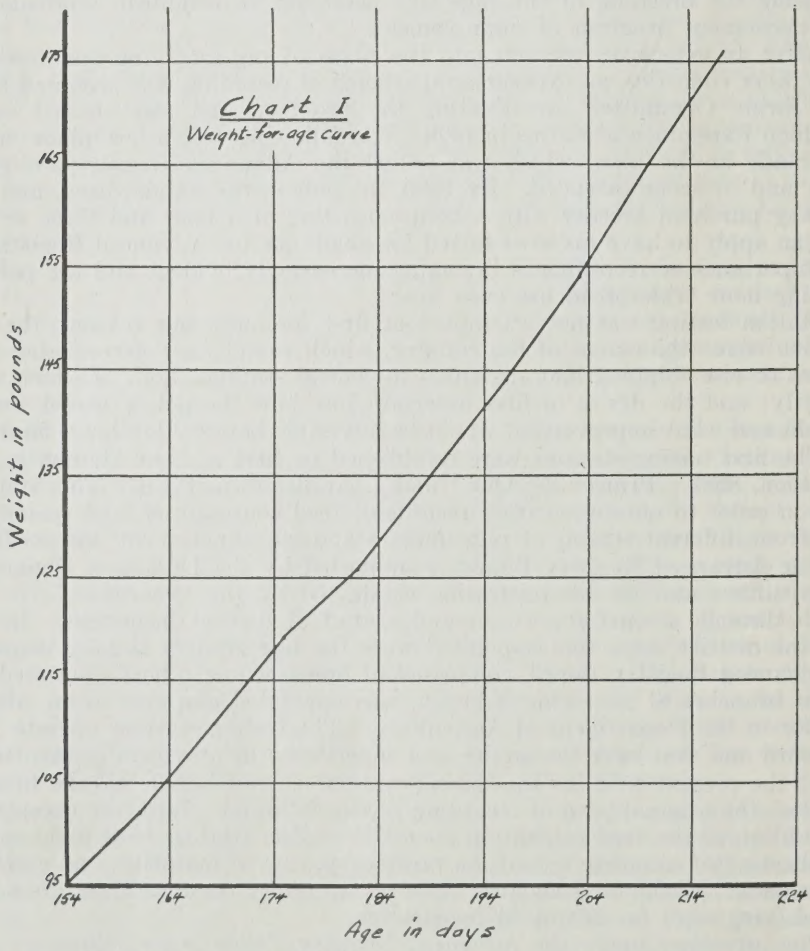

CHART I.—Weight-for-age curve (Duckham) showing the derivation of "standard" age.

an average minimum *Maturity Index* of 100. Thus, a sow having progeny making faster gains than the minimum required will score more than 100, while a sow producing slow maturing pigs would net less than 100 and fail to pass in this division.

The *Slaughter Test* is the attempt to measure the commercially important characteristics of the carcass. The measurements and grades taken are those deemed most suitable to estimate the quality or value of the carcass. Chart II is a diagram showing the points at which the measurements are taken and the cuts made.

When the pigs have reached market weight, they are shipped to a designated abattoir and pass through the slaughter test as follows: (This is given in detail as the data on carcass measurements used in this study were collected under this procedure).

(*a*) The hogs are slaughtered as soon as possible after arrival at the packing plant. The carcasses are split down to the head and a hot weight taken with the kidneys and leaf lard included.

(*b*) The carcasses are placed in the cooler for 48 hours, after which they are removed and the measurements taken.

(*c*) The cold carcass weight is taken, also with the kidneys and leaf lard included.

(*d*) The head is cut off as shown in the chart and the feet removed at the knee and hock joints.

(*e*) The leaf lard and kidneys are removed.

(*f*) The sides of the carcass are placed on a table and the length of each taken from the lower side of the aitch bone to the anterior edge of the first rib (A-B in Chart II).

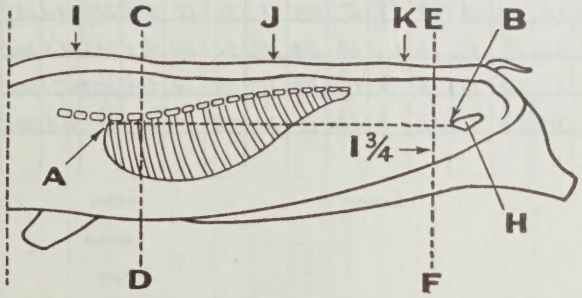

CHART II.—Length is taken between points A and B. Back fat measurements are taken at I, J, and K. The shoulder is cut as at C D and the ham as at E F, 1¾ inches from the aitch bone, H.

(*g*) Fat measurements, i.e., maximum shoulder fat depth, minimum back fat, and maximum loin fat are taken at the points stated along the back fat. The depth of carcass at heart and flank are taken where the shoulder and ham cuts are made, respectively.

(*h*) The fat is graded for firmness into classes: very firm (VF), firm (F), fairly firm (FF), slightly soft (SS), soft (S), or very soft (VS).

(*i*) The carcasses are graded as leanest (LL), lean (L), prime (P), or unfinished (U).

(*j*) Both hams are cut off squarely at the point exactly one and three-quarter ($1\frac{3}{4}$) inches in front of the aitch bone (E-F).

(*k*) Both shoulders are cut squarely through the middle of the third rib (C-D).

(*l*) The weights of the two shoulders, middles, and hams, respectively, are taken. The percentages, later calculated, are the proportions that each of the three parts, as cut, make of the carcass.

(*m*) In order to grade the belly for quality, the tenderloin is removed. The grades given are: excellent (E), good (G), fair (F), or poor (P), according to general firmness, evenness, uniform thickness and quality.

(*n*) There is no further cutting or trimming, other than described. The utmost care is taken to attain the highest degree of accuracy in these measurements.

These data are recorded on cards, a sample of which is presented in Figure I. When the individual pigs of a litter are slaughtered at different times, separate cards are made for each pig, or group, slaughtered. The completed slaughter test report of the litter is forwarded to the central office at Ottawa, where the age at slaughter of each pig, the maturity index and carcass score of the litter, are calculated.

The carcasses of four pigs are scored on the basis of deductions from an arbitrary perfect score. The scoring chart is presented in Chart III. Under carcass score a sow must secure 75 per cent of the total number of points (100) possible. Attention is directed to the deductions of overweight carcasses. For each carcass weighing more than 160 pounds (cold) two points are deducted from the carcass score for the litter.

FORM S. E. T.—REV. 1M-8-39 LOWE-MARTIN CO. LIMITED—046661A

SLAUGHTER TEST REPORT

LITTER IDENTIFICATION XT 21

PIG No.	CARCASS WEIGHTS HOT	CARCASS WEIGHTS COLD	MEASUREMENTS LENGTH Right Side	LENGTH Left Side	Shoulder Fat	Back Fat	Loin Fat	Min. Belly	Max. Belly	Width Flank	Width Heart	WEIGHTS OF CUTS Hams	Middles	Shoulders	PERCENTAGES OF CUTS Hams	Middles	Shoulders	SCORING Belly	Fat Firmness	Grade	Class
64	160	155	31½	32	2½	1⅛	1¾	¾	2	11½	13	31	66	39½	22.7	48.4	28.9	E	VF	LL	1
59	162	155	32	32	1¾	1	1¼	1	1½	11½	14½	32	64	41½	23.3	46.5	30.2	G	FF	LL	1
67	151	145	31	31	1⅞	1	1¼	⅝	1¾	10¾	11	29	60	38½	22.7	47.1	30.2	F	FF	LL	1
61	157	151½	33	33½	1⅞	1	1½	⅝	1¾	11	14	32	61	40	24.1	45.9	30.0	G	VF	LL	1

DATE OF SHIPPING SLAUGHTER CUTTING

BREEDER'S NAME ABATTOIR

ADDRESS PLACE

SHIPPED BY: EXPRESS ☐ FREIGHT ☐ TRUCK ☐ FROM: ABOVE ☐ FEEDING STATION AT

SCORE (LEAVE BLANK) MEASURED BY

(OVER)

Figure I.—A sample slaughter test report card.

To qualify and receive an Advanced Registry number, a sow must pass all three divisions of the test, i.e., secure not less than 40 points for prolificacy, 75 for carcass excellence, and 100 as a maturity index. A certificate of qualification is issued for successful sows with the scores obtained under the three divisions stated. The detail of the points secured under the various divisions of the carcass score is also included on the certificate. When a boar sires three litters which qualify, he also is given an Advanced Registry number.

The qualified sows and boars are listed and published from time to time, and the pedigree registration certificate for swine, as issued by the Canadian National Live Stock Records, includes the Advanced Registry number of all qualified animals appearing as ancestors in the pedigree.

CHART II.—CARCASS SCORING CHART FOR LITTER OF 4 PIGS

Factors used in Scoring	Length of Carcass	Back Fat		Balance of Side			Belly Grade
		Thickness	Evenness	Ham	Middle	Shoulder	
Perfect score	24	12	12	9	9	9	25
Standard required for perfect score	30½ inches or more	Maximum 2 inches Minimum 1 inch	Not more than ¾" difference between Maximum and Minimum	Not less than 25% (Of total weight of three cuts)	Not less than 50% (Of total weight of three cuts)	Not more than 25% (Of total weight of three cuts)	Must grade "Excellent" (E)
Points deducted for each fault from standard.	30–30⅜" ..... 1 29½–29⅞ ..... 2 under 29½ 6	2	2	1 (For each percentage)	1 (For each percentage)	1 (For each percentage)	Good (G) .....2 Fair (F) .....4 Poor (P) 6

NOTE.—Two points from total score are deducted for each carcass weighing over 160 pounds.

B. OBJECTS OF STUDY

Considerable data have accumulated since the Canadian Advanced Registry Policy for Swine was started in 1928, and, while the records have been published periodically, no critical study had been made of the data when this project was undertaken. Specifically, the objects of this study are:—

1. To study what trends have taken place over the six-year period, 1929-34, in such characters as rate of maturity, length of side, and uniformity of fat of hogs tested under the Advanced Registry.

2. To discover what, and how much variability, in the characters measured, is attributable to differences between (*a*) stations, (*b*) years, and (c) sows.

3. To study the correlations between the various carcass measurements, and the relationship, if any, between these measurements and the feed records.

4. To study the relative influence of certain characteristics on the carcass score, and average depth of back fat.

5. To investigate, with frequency distributions of the deductions from the perfect scores, the characteristics in the Experimental Farms' pigs which do or do not meet the standards set up under the Advanced Registry Policy.

II. METHODS OF INVESTIGATION

A. SOURCE OF DATA

The data used in this study were collected under the Advanced Registry policy and made available through the co-operation of the Dominion Live Stock Branch and the Dominion Experimental Farms. Since the policy was inaugurated the Experimental Farms Branch has played a prominent part in its development. With swine herds on stations in all the provinces, the farms have tested a large number of sows, and, even though not required by the policy, have also recorded the feed consumption and periodic gains made.

1. Feed and Gain Records

In 1929, the Central Experimental Farm at Ottawa outlined in general the management and rations to be followed on the various farms in the system in testing sows under the Advanced Registry policy.

In most cases, the five pigs nominated for the slaughter test were started on a weanling ration when approximately eight weeks of age, and after 60 days feeding were changed to a growing ration. Thirty days later, or when the pigs had been on feed 90 days, a finishing or fattening ration was introduced and fed until the hogs were ready for market. The degree of finish carried by the hogs determined when they should be marketed, and this point was generally reached at a live weight of 195 to 210 pounds. The weights of the pigs and the feed consumed were recorded at 30-day intervals.

Typical meal mixtures used are given in Table I.

TABLE I

Feed	1st 60 days	60 to 90 days	90 days to finish
	lb.	lb.	lb.
Middlings	200	100	–
Ground oats	175	200	150
" corn	50	100	200
" barley	50	100	100
Shorts	50	50	100
Bran	25	–	–
Linseed oilmeal	18	18	18
Tankage, 50 per cent	18	18	18
Bone char	6	6	6
Salt	3	3	3
Skim-milk or buttermilk	(hand-fed)	(hand-fed)	(hand-fed)

The proportion of skim-milk or buttermilk to meal fed in these rations was reduced as the pigs progressed, thereby lowering the level of protein as the pigs developed. While this ration was followed in general, some alterations, due to unavoidable circumstances at certain stations, were necessary. Green feed was utilized where available, and generally was in the form of roots, clover, or alfalfa.

The essential data from these feeding tests, collected by the 19 stations included in this study, were taken from the records assembled in the Animal Husbandry Division at the Central Experimental Farm in Ottawa.

2. Advanced Registry Data

The records on prolificacy, rate of maturity, and carcass measurements (see page 8) were taken from the files of the Dominion Live Stock Branch.

There were available for this study the records on 370 sows or litters, accumulated in the six-year period 1929-34. The limits of this study made it impossible to treat the 1,480 pigs involved individually, and hence, the averages of the four pigs from each sow in so far as the different items of the slaughter test were concerned, and of the five pigs of each litter fed together in the case of the feed and gain records, were used as single observations.

The Experimental Farms or Stations are referred to in this study as "stations." The detailed distribution of the sows by stations by years is given in Appendix Table I.

A sow may fulfil the requirements for Advanced Registry with but one litter. If she does not qualify, however, she may be entered to try the test again with a later litter. In the 370 litters included in this study, 60 are such duplicates, and in 12 other cases, sows appear with three different litters. There are three breeds represented: Yorkshires with 337; Berkshires 18; and Tamworths with 15 litters. Any effect on the data of duplicate litters or different breeds, however, has been disregarded, and the entire population considered a representative sample of Canadian hogs.

B. PREPARATION OF DATA

To facilitate subsequent statistical analysis the data were transferred to cards, a sample of which is shown in Figure II.

The upper section of the card indicates the identification of the sow and litter. The sex of the pigs is designated by underlining the numbers of the barrows. Hence, pigs 64 and 61 are barrows, and 59 and 62 gilts.

The initial weight, gain, days on feed, and daily gain were taken directly from the Experimental Farms records. The feed consumed by the five pigs was converted to an air-dry (90 per cent dry matter) basis. In making this conversion the following moisture contents were assumed: grain, 10 per cent; milk, 90 per cent; roots, 91 per cent; and green feed, 75 per cent. The daily feed and the feed/gain ratio (pounds of feed required for 100 pounds gain) were calculated using the "air-dry" feed. The feed/carcass gain ratio (pounds of feed required for 100 pounds carcass gain) required the estimation of the weight of the carcasses of the four pigs at the start of the test. The dressing percentage of a weanling pig (ranging from 20 to 40 pounds) was taken as 65 per cent. This figure is being used by the Live Stock Branch in similar work and approximates the figure (66·2 per cent) which Whetham (1935) reports as the dressing percentage of 60-pound Large White pigs.

The maturity index and carcass score were taken from the Advanced Registry records. The hot and cold carcass weights and the percentage cuts are copied directly from the records as shown in Figure I.

The linear measurements of length, depth, back fat, and belly thickness were taken in the slaughter test in inches and fractions of inches. As the fractions involved (such as halves, quarters, eighths and sixteenths) were cumbersome, it seemed advisable to code these measurements. This was done by expressing all such measurements as sixteenths, i.e., the 32 inches length is shown as 512, and the $1\frac{3}{4}$ inches loin fat becomes 28.

When the average per-pig figures were calculated, the decimals involved were handled as follows: with an average of over 100, no decimals were retained; over 10 and under 100, one decimal; while with average of one digit, two decimals were kept.

Station. Index:	F 31	Sow: 146565	XT 21
Boar. Index:	134120	Litter:	1
Pigs born:	10	Pigs weaned:	9

	Total 5 Pigs	4 pigs	Av. per Pig
Int. Wt.	132		26.4
Gain	929		186
Days on feed	680		136
Daily gain	1.37		1.37
Feed (air-dry)	3690	2952	738
Daily Feed			5.43
Feed / gain ratio			3.97
Feed / carcass ratio			5.49
Mat. Index		113	
Carcass Score		74	
Carcass gain		537.4	
Av. depth fat			23.8

(10-10) x 317 File No.: 313 x

Pig Nos.	64	59	62	61	Total	Av. per pig
Age at slaughter	185	178	178	171	712	178
Wt. hot	160	162	151	157	630	157
Wt. cold	155	155	145	151	606	151
Length	512	512	496	536	2056	514
Fat....Shoulder	40	28	30	30	128	32.0
Back	18	16	16	16	66	16.5
Loin	28	20	20	24	92	23.0
Max. Dif.	22	12	14	14	62	15.5
Firmness	1	3	3	1	8	2.00
Belly....Min.	12	16	10	10	48	12.0
Max.	32	24	28	28	112	28.0
Grade	1	4	7	4	16	4.00
Depth....Flank	184	184	172	176	716	179
Heart	208	232	176	224	840	210
% Ham	22.7	23.3	22.7	24.1	92.8	23.2
% Middle	48.4	46.5	47.1	45.9	187.9	47.0
% Shoulder	28.9	30.2	30.2	30.0	119.3	29.8

Figure II.—A sample data card used in this study.

One of the problems encountered in this study was the use to which the three measurements of back fat should be put. It was first thought that if they were treated separately much valuable information might be derived, particularly with reference to their relation to the other carcass measurements. However, after noting that both the Danish and American plans of testing averaged the five measurements of back fat taken, and that other workers have shown the average depth of back fat to effect the percentage carcass yields (Scott, 23), and to be indicative of the total fat in the carcass (Hankins and Ellis, 18), it was decided to average the three measurements taken. This figure was calculated by adding the three measurements from each of the four pigs of a litter and dividing by 12 (in the sample card this average is shown as 23·8). The maximum difference between any two of the three measurements was taken for the purpose of this study to represent uniformity of fat. The two items, firmness of fat and belly grade, were given numerical values as shown in Table 2.

TABLE 2

Firmness of fat		Belly grade	
Grade	Value	Grade	Value
Very firm (VF)	1	Excellent (E)	1
Firm (F)	2	Very Good (VG)	2
Fairly firm (FF)	3	Good plus (G+)	3
Slightly soft (SS)	4	Good (G)	4
Soft (S)	5	Good minus (G−)	5
Very soft (VS)	6	Fair plus (F+)	6
		Fair (F)	7
		Fair minus (F−)	8
		Poor plus (P+)	9
		Poor (P)	10
		Very poor (VP)	11

In the few cases where only four of the five nominated pigs completed the feeding test, it was assumed that all pigs, up to the stage any one was removed, had consumed the same amount of feed, and adjustments for feed and gains were made on a *pro rata* basis.

It should also be reported that at Lacombe from 1929 to 1932, all pigs of a litter were fed together (instead of only the five nominated), and the feed and gain figures from this station for those years were, therefore, averages calculated from the full litter records.

C. STATISTICAL ANALYSIS OF DATA

1. Analysis of Variance

The first step, after the data had been coded, copied, and averaged, as described, was the analysis of variance of the following items: carcass score, maturity index, age at slaughter, cold carcass weight, gain per pig, feed per pig, feed/carcass gain ratio, initial weight, daily gain, length of side, average depth of fat, maximum difference of fat, firmness of fat, minimum belly thickness, belly grade, per cent ham, per cent middle, and per cent shoulder.

The figures used in all cases were the per-pig averages and the method of analysis was that proposed by Fisher (14). The standard deviations and coefficients of variability of stations and years, i.e., the variability due to between stations and between years, were calculated by using the station and year means. Because of the small number of sows tested at Charlottetown, La Ferme, Kapuskasing, and Swift Current, these were not included when the between-station standard deviations were calculated.

TABLE 3—ANALYSIS OF VARIANCE OF CARCASS SCORE *

Variance due to	Degrees of freedom † (D/F)	Sums of squares (S.S.)	Variance (M.S.)	Standard deviation (S.D.)	Coef. of variability (C.V.)
Total	369	47557.4279	128.8819	11.35	16.06
Between stations	18	13179.6806	732.2045		
Within stations	351	34377.7473	97.9423	9.90	14.01
Between years	5	7313.2050	1462.6410		
Within years	364	40244.2229	110.5611	10.51	14.87
Between sow-groups	70	30986.7570	442.6679		
Within sow-groups (Between sows)	299	16570.6709	55.4203	7.444	10.53

* General mean of carcass score=70·66

† 370 sows, 19 stations, 6 years, and 71 sow-groups.

The within sow-group variance, by being calculated between litters of a group at any station in any year, is actually a measure of the variability between sows after other effects, such as station and year, have been removed and is used in this study as the "error" variance. The mean squares and standard deviations associated with this division of the analysis for the various characters are used exclusively in the determination of the simple correlation and regression coefficients. The procedure followed in calculating these coefficients was that described by Crampton (5).

2. Analysis by Method of Partial Regression

In order to study the relative effect of certain factors upon the carcass score and their inter-relationship, the method of partial regression was used. In solving the simultaneous equations necessary to calculating the partial regression coefficients, the procedure followed was that proposed by Wallace

and Snedecor (28). In group I, carcass score was the dependent variable and feed/carcass gain ratio, maturity index, and firmness of fat, the independent variables. In group II the relative effect of the percentage cuts—ham, middle, and shoulder—on the average depth of back fat was studied.

III. RESULTS AND DISCUSSION

A. TRENDS

The first phase of this problem investigated concerned the trends that had taken place over the period represented. The yearly averages of the 21 characters involved are given in Table 4, and certain of the trends are shown in graph form in Charts IV, V, and VI. In the preparation of these charts, the yearly averages were reduced to a convenient system of index figures.

These data include some sows representing the second and third generation recorded. While it is reasonable to assume that some of the improvement noted in the characters over the period might have been accomplished by selection alone, or is a result of the suspension of recording at certain stations, it is likewise probable that recording under the Advanced Registry Policy not only provided a much broader basis for selection, but in addition, hastened the progress and made it more consistent and permanent.

TABLE 4—AVERAGES OF CHARACTERS BY YEAR

Year		1929	1930	1931	1932	1933	1934	General Mean (all litters)
Number of sows		104	92	60	49	32	33	370
Advanced Registry Scores—								
Carcass score		64·1	70·9	73·3	73·9	74·6	77·1	70·66
Maturity index		98·5	105·7	107·1	107·7	111·4	108·8	104·9
Age and weights—								
Age at slaughter	dys	206·6	193·5	187·5	189·6	183·5	186·3	194·2
Initial weight	lb.	26·3	29·1	30·6	32·5	32·9	36·2	29·96
Cold carcass wt	lb.	152·4	155·5	150·0	154·6	155·0	153·7	153·4
Gain and feed—								
Gain	lb.	184·0	183·3	176·7	177·7	177·8	174·1	180·4
Daily gain	lb.	1·23	1·34	1·33	1·40	1·40	1·36	1·32
Feed	lb.	701·7	715·7	657·2	685·4	644·4	658·5	687·0
Feed/gain ratio		3·82	3·90	3·73	3·91	3·62	3·77	3·81
Feed/carcass gain ratio		5·19	5·23	5·05	5·17	4·82	5·06	5·13
Carcass measurements—								
Length and depth—								
Length of side	inch	29·61	30·59	30·96	31·08	31·07	31·23	30·54
Depth—flank	"	12·35	12·00	12·15	11·68	11·30	11·11	11·94
" —heart	"	13·78	13·71	13·61	13·63	13·58	13·57	13·68
Fat—								
Average depth	inch	1·40	1·48	1·43	1·42	1·35	1·43	1·43
Max. difference	"	·807	·729	·781	·777	·763	·763	·772
Firmness	index	2·62	2·20	2·29	1·79	1·86	1·99	2·23
Belly—								
Min. thickness	inch	·745	·826	·877	·861	·825	·931	·826
Grade	index	5·00	4·87	4·62	3·85	3·77	3·93	4·55
Percentage cuts—								
Ham	%	26·88	24·77	23·78	24·14	24·35	23·84	25·00
Middle	%	44·83	46·03	46·75	46·00	46·60	47·09	46·03
Shoulder	%	28·29	29·20	29·47	29·26	29·05	29·07	28·97

In carcass score, there has been a steady and decided improvement (Chart IV, *a*). The average carcass score increased from 64·1 in 1929 to 77·1 in 1934 (Table 4). This increase undoubtedly was influenced by the suspension of testing at certain stations, but it was also the result of selection based on information gathered under the Advanced Registry Policy.

The rate of maturity, as indicated by the maturity index, has also improved over the period. With this improvement there is closely associated the decrease in the average age of the pigs at slaughter (Chart IV, b). The average cold carcass weight is included in Chart IV (b), and although this average has not varied appreciably in the six years, it was noted by inspection of the data that carcass weight has been more uniform in recent years. The fact that over-weight carcasses are subject to penalties in the carcass score has drawn attention to this feature, and this greater stability observed has, no doubt, been the result of a more definite understanding of market requirements.

In the Advanced Registry carcass score, particular attention is given length of carcass. As a result of penalizing carcasses below a minimum length of 30·5 inches, there is noted an increase of 1·62 inches in the average length over the six-year period. With this increase in length, there is a slight gradual decrease in depth of side at the heart and a more decided reduction at the rear flank (Chart V, a). In reporting on progeny testing in Denmark, Lush (1936) shows that over the period 1926-35, the Danes have increased the average length of their hogs 2·5 centimetres (about one inch). He further intimates that in his opinion this was no accident, but rather the result of testing and systematic selection.

With respect to balance of side, the per cent shoulder shows little change over the period, whereas the per cent ham has decreased and the middle increased (Chart V, b). In these data, there exists a significant correlation between middle and ham, and middle and shoulder, but no apparent relation between ham and shoulder (see Table 5). It will also be observed that the per cent shoulder is consistently high as compared to the standard of 25 per cent set in the scoring chart (Chart III, page 11). Concerning light shoulders, Hammond (16) states: "The shoulder is a low-priced part of the carcass as compared with the loin and consequently should be reduced as far as possible. There is a natural tendency in pigs, following their wild boar ancestor, to become heavy in the shoulders and light in the loin, and this fault will tend to creep in unless continual selection is made against it."

The need for a light shoulder has been recognized and selection has been made accordingly, but with seemingly little success. It would appear that judging standards may be lacking in this direction. Calder (3) says: "The opinion is widely held that fineness of shoulder is closely associated with lack of constitution resulting from underdevelopment of the chest. There might be some justification for this opinion if the lungs and heart were placed between the shoulder blades—chest capacity, however, is primarily determined by fulness of girth and spring of rib. Fineness, or otherwise, of the shoulder has little, if any, bearing on the development of the girth." What constitutes a light shoulder is certainly elusive and the external indications are few. The smoothly laid-in shoulder, it would seem, may or may not be relatively light. At the same time, it is the opinion of some that certain strains of pigs have a balance of carcass definitely and consistently better than others, and improvement would result from a further use of individuals from the strains superior in this feature.

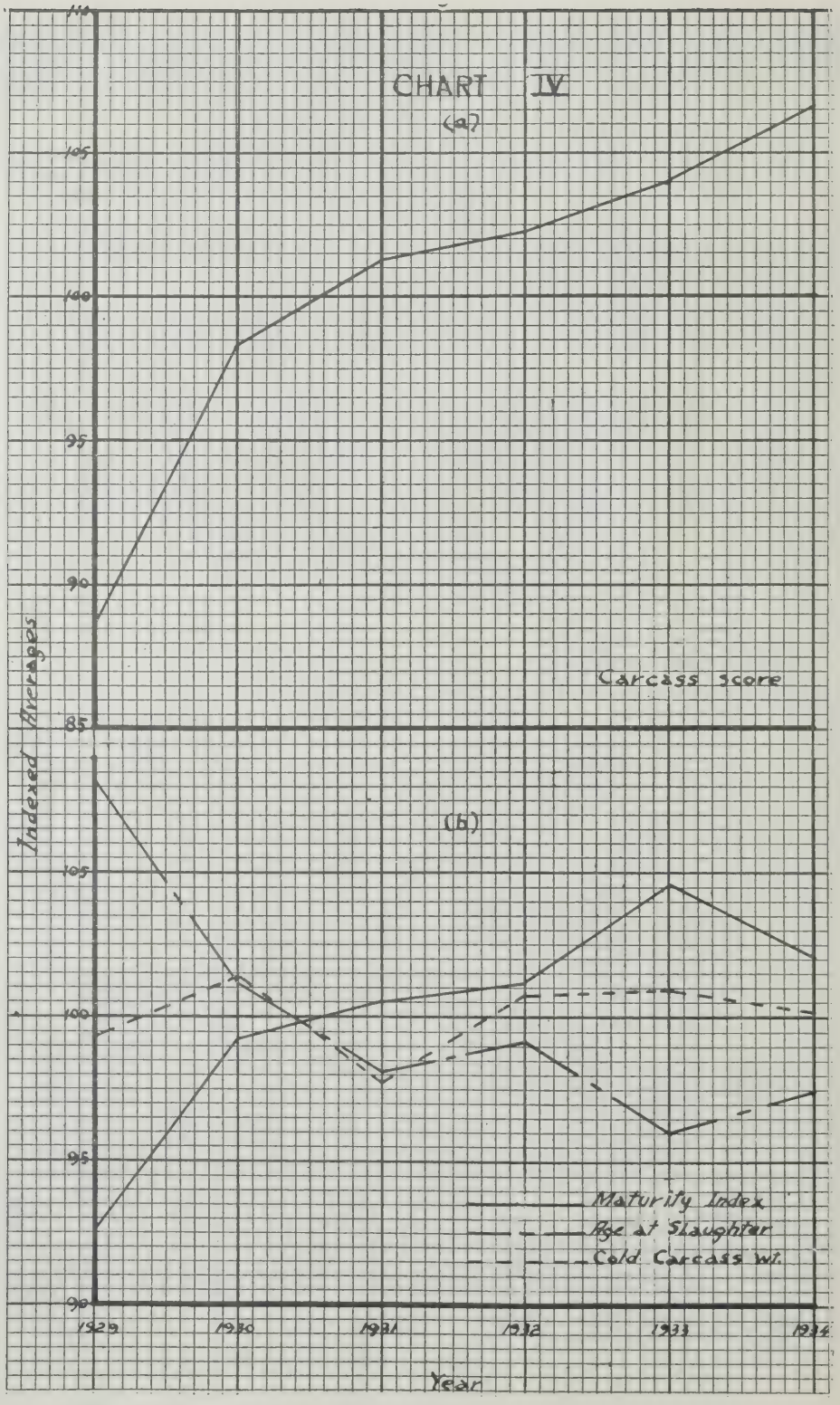

CHART IV. Trends in: (*a*) Carcass score.
(*b*) Maturity index; age at slaughter; cold carcass weight.

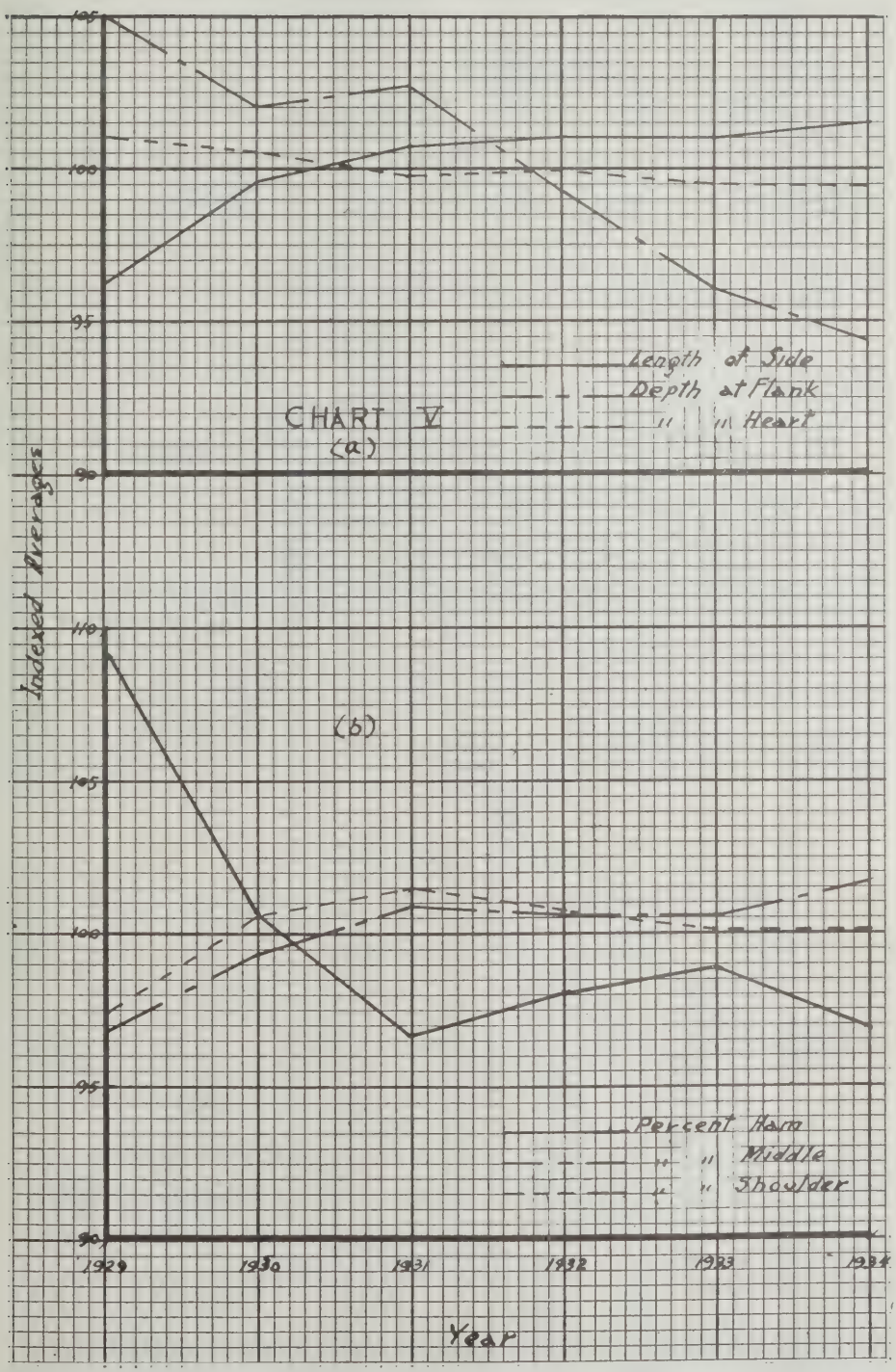

CHART V. Trends in: (*a*) Length of side; depth at flank; depth at heart.
(*b*) Per cent ham, middle, and shoulder.

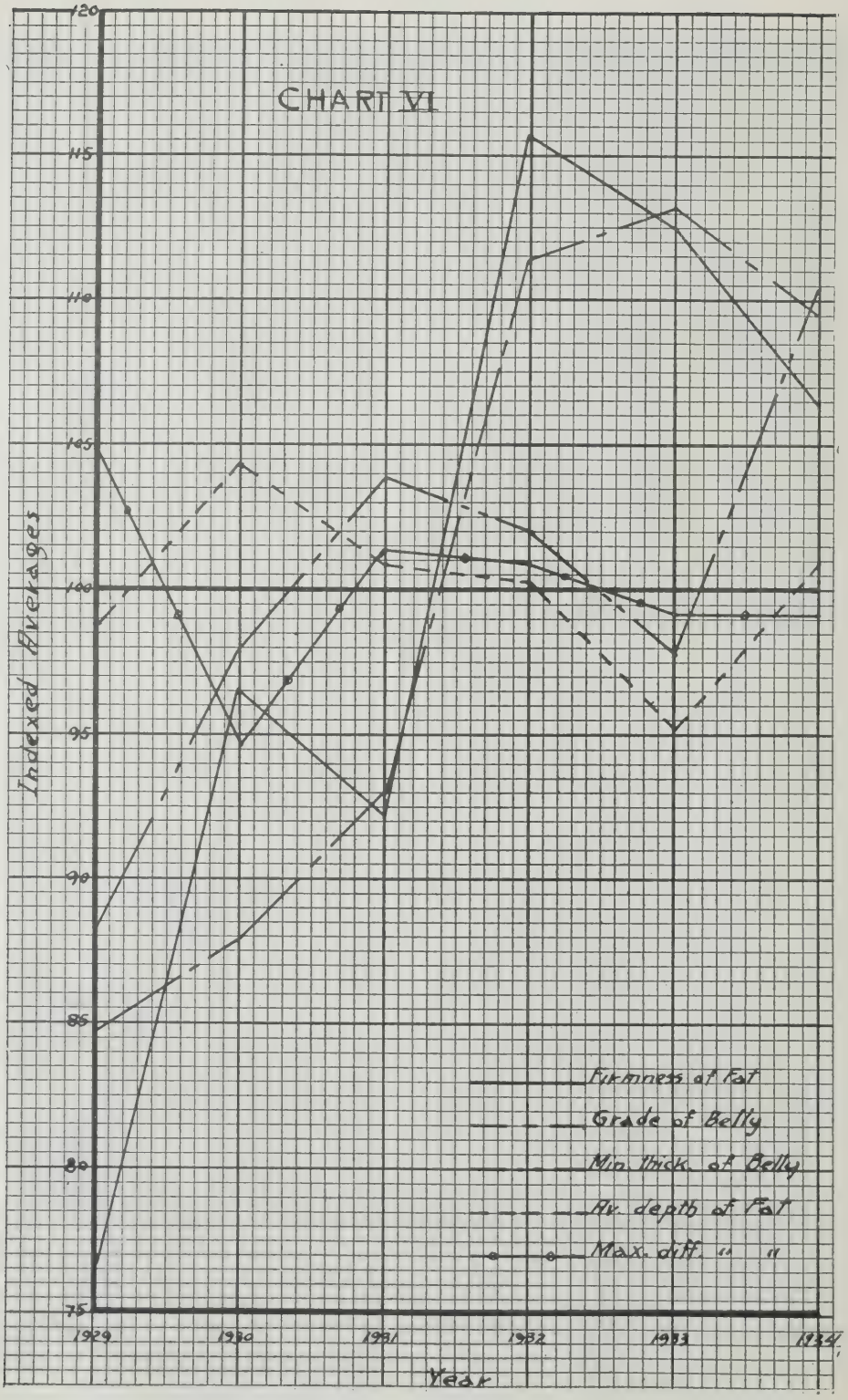

CHART VI. Trends in: Firmness of fat; grade of belly; minimum thickness of belly; average depth of fat; maximum difference of fat.

In Table 4, it will be noted that the average depth of fat has been quite stationary while the minimum thickness of belly has increased steadily (Chart VI). In these characteristics, Lush (20) shows that the Danish breeders, in catering to the British market, have been successful in their attempt to reduce the average depth of back fat and increase the thickness of belly. In fact, he intimates that they have reduced the average depth of fat to the extent that it has affected the firmness of the carcass. In the Canadian testing policy, while minimum and maximum limits are set for thickness of fat, particular attention is not directed to the average depth. The average is given in these data only for the purpose of this study. However, the Advanced Registry does take into account the uniformity of fat thickness, and this feature, as measured by the maximum difference between any two of the three measurements of back fat taken, shows a slight improvement over the period covered by this study (Chart VI).

The average firmness of fat and belly grade are also shown in Chart VI. The averages in Table 4 indicate that the firmness of fat has improved from an average of "fairly firm" in 1929 to "firm" in 1934, while the average belly grade changed from "good minus" to "good."

The station averages of the characters for the six-year period are included in Appendix Table II. The averages are somewhat influenced by the numbers involved and by the years in which the sows were tested. For instance, some of the stations recorded sows only for the first two or three years, and hence, the station averages should be studied in the light of the distribution of sows, which is given in Appendix Table I. Certain differences confined to geographic location will be noted; for example, the feed required per pound carcass gain (feed/carcass gain ratio) is greater in the Prairie Provinces. The uniformity of fat and thickness of belly seem consistently better in the West, but the firmness of fat slightly poorer in Manitoba and Saskatchewan. The rate of maturity was slower on the Prairies while in most of the other characters little difference is noted on the various stations.

B. VARIABILITY STUDIES

Culbertson, Evvard, Kildee, and Helser (6), Ferrin and others (12), and Taussig (27), report that wide variations exist in pig testing records. The measurement of the extent of this variability in the Canadian records was one of the primary objects of this study, particularly with respect to the effect of stations and years as compared to that between the sows themselves. The analysis of variance as proposed by Fisher (14) was used in this phase of the study as was previously described (page 15). The total variance was partitioned in three ways: (1) between versus within stations; (2) between versus within years; and, (3) between sow-groups versus within sow-groups. The coefficients of variability from the "within" variances thus determined are given in Table 5. The "between" station and year coefficients were calculated, as previously intimated, using the station and year averages.

The between figures of station and year measure the variation due to differences in strains of pigs, management and feeding from station to station, or the improvement from year to year, as the case may be, while the "within" figures contain all the factors causing variation within the stations or within the years. These latter may be influenced in part by diseases, parasites, and season. Particular attention is directed to the "within sow-group" variability, which is the measure of difference between individual sows. It will, hereinafter, be referred to as "between sows".

TABLE 5—COEFFICIENTS OF VARIABILITY *

Character	Stations		Years		Sow-groups
	Between	Within	Between	Within	Within (Between sows)
Degrees of Freedom	14(†)	351	5(†)	364	299
	%	%	%	%	%
Advanced Registry Scores—					
Carcass score	9·6	14·0	6·2	14·9	10·5
Maturity index	5·4	7·1	4·1	7·5	4·7
Age and weights—					
Age at slaughter	5·3	7·8	4·3	7·9	5·4
Initial weight	14·1	21·6	10·9	22·2	13·9
Cold carcass weight	2·5	4·0	1·3	4·3	3·3
Gain and feed—					
Gain per pig	3·9	5·3	2·2	6·1	4·3
Daily gain	23·0	10·7	4·7	11·7	7·0
Feed per pig	15·1	10·9	4·2	17·1	8·2
Feed/carcass gain ratio	14·4	10·3	2·9	16·3	7·3
Carcass measurements—					
Length—					
Length of side	1·7	3·2	2·0	2·9	2·1
Fat—					
Average depth of fat	4·6	9·2	3·1	9·8	7·9
Max. diff. fat	15·8	16·6	3·3	20·9	15·5
Firmness of fat	32·3	29·7	14·7	39·2	23·4
Belly—					
Min. thickness of belly	15·5	17·0	7·4	20·0	12·9
Grade of belly	27·3	35·8	12·7	40·7	31·5
Percentage cuts—					
Per cent ham	3·3	5·9	4·7	4·2	3·2
Per cent middle	1·7	3·5	1·7	3·5	2·6
Per cent shoulder	2·5	4·3	1·4	4·5	3·2
Average	11·0	12·1	5·1	14·1	9·3

* Standard Deviations expressed as % of the general mean of the characters; General means shown in Table 5.

† The Standard Deviations of characters "between" stations and years calculated by using the station and year means. Four stations, namely, Charlottetown, La Ferme, Kapuskasing, and Swift Current, were not included because of the small number of sows tested, hence, the fourteen (14) degrees of freedom for between stations.

The variance or M.S. (Mean Square) for the six divisions of the analysis of eighteen characters is presented in Appendix Table III. It is to be noted that in only one instance is the variance due to station and year differences not significant over the respective within or remainder variance. With the feed/carcass gain ratio it would appear that differences due to year are not significant. The analysis of variance indicates that the characters measured under the Advanced Registry are influenced by real differences due to different stations and different years. However, it should be borne in mind that owing to the unequal distribution between years and stations, the portion of the variance between stations might have arisen from differences between years, and vice versa.

In connection with such influencing factors which are in most cases differences in feeding and management, Hammond (15) says: "No reference has been made . . . . . to the influence of hereditary factors in relation to feeding and management, although it is very evident that they exist. Pig recording, just as milk recording, offers great possibilities for improvement in this direction, not only by direct selection for the qualities required through progeny tests, but also by improving the environment in which the selection is made; for frequently under present conditions the true genetic qualities of the animal get no chance of expressing themselves owing to defects in the environment." This study

would thus indicate the necessity of eliminating the effects of environment from testing records, and further supports the move of the Advanced Registry Board in adopting in 1934 testing stations as part of the swine improvement program.

While the outline for the feeding and management of the pigs used in this study was set forth at the outset of the recording by the Central Experimental Farm at Ottawa, it was not possible, due to unforeseen circumstances arising at certain stations, to follow it to the letter. With the advent of testing stations where a standard procedure and ration is definitely followed, much of this variability, due to environment, will undoubtedly be eliminated and a more authentic picture of the relative productive ability of sows established.

The coefficients of variability presented in Table 5 indicate the degree the different characters vary about their means in the divisions of the variance. Certain features are of special interest. In the two divisions of the station variability, for instance, though the average of all the characters for both portions are nearly the same, the fact that in daily gain, feed per pig, feed carcass gain ratio, and firmness of fat the coefficients between stations are greater than those within, seems significant. These four factors are immediately associated with feeding and management practices, and such suspected differences between stations are apparent.

A relatively high variability is to be noted in initial weight, daily gain, feed consumed per pig, uniformity of fat, firmness of fat, minimum thickness of belly, and belly grade. The initial weight is influenced by the age at which the pigs are weighed for the start of the test. It is evident that the practice in this connection varied considerably between stations and from year to year. The wide variations between stations in daily gain, feed per pig, and economy of feed utilization, as measured by the feed/carcass gain ratio, as was previously intimated, are influenced by many factors of which the inherent ability of the different strains of pigs at the various stations to utilize feed is probably a major one. Culbertson *et al* (6) have also noted wide variations in the efficiency of feed utilization.

The uniformity of fat, or maximum difference of fat, and minimum thickness of belly have, to a degree, a similar distribution of their variability. The one exception to be noted is in the "between years" coefficients, where it would seem that the greater improvement in thickness of belly, from year to year (*see* Table 4 and Chart VI) has materially influenced the coefficients of that character, and it is more than twice that of the uniformity of fat between years.

As compared with any of the other characters, firmness of fat and belly grade have particularly high variabilities in all divisions of the analysis. This is no doubt due to a degree at least, to the fact that these grades are matters of personal judgment. Table 5 further indicates that the average cold carcass weight, length of side, and percentage cuts were quite consistent across the Dominion and over the period studied.

It is suggested from this study that future analysis would be materially facilitated if all linear measurements of carcass data were taken in inches and tenths of inches.

C. CORRELATION STUDIES

The relationships between the measurements studied are expressed as simple correlation coefficients in Table 6. The simple regression coefficients are also included. In all cases, the co-variance used was that "within sow-groups" (between sows) and the standard deviations and variances involved in calculating the coefficients of simple correlation and regression are included in Appendix Table IV. With the 299 degrees of freedom available, the correlation (r_{xy}) necessary for significance, is shown by Wallace and Snedecor (28) to be ·113 at the 5 per cent point and ·148 at the 1 per cent point. Hence, all correlations in Table 6 greater than these values (particularly the 1 per cent level) may be considered as indicating significant relationships.

Considerable care, however, must be exercised in interpreting the simple correlations, since it may be that an inter-relationship of other characters influences the observed result. For this reason, the simple correlation cannot safely be interpreted in terms of cause and effect without carefully considering the nature of the characters involved.

TABLE 6—SIMPLE CORRELATIONS[1] AND REGRESSIONS

No.	x	y	S(xy)	Mean co-variance	r_{xy}	Co-variance $\sigma^2 x$ b^i	Co-variance $\sigma^2 y$ b''
1	C	Ff	−281·26563	−·940688	−·2417	−·0170	−3·4457
2		F/C	−62·10853	−·207721	−·0746	−·0037	−·1489
3		I	774·25173	2·589471	·0701	·0467	·1050
4	L	Fa	−274·86761	−·919290	−·0509	−·0092	−·2805
5		Fd	−82·23857	−·275045	−·0143	−·0027	−·0749
6		Ff	190·75853	·637988	·1219	·0064	2·3366
7		Bg	182·16266	·609240	·0425	·0061	·2966
8		H	26·08092	·087227	·0110	·0009	·1389
9		M	2·60416	·008709	·0007	·0001	·0061
10		S	−28·67416	−·095900	−·0104	−·0010	−·1133
11		F/C	−25·23850	−·084410	−·0225	−·0008	−·6051
12		I	2108·75156	7·052681	·1419	·0704	·2859
13	Fa	Fd	31·45111	·105188	·0304	·0323	·0287
14		Ff	−48·86904	−·163442	−·1732	−·0502	−·5986
15		Bg	−192·81326	−·644860	−·2494	−·1981	−·3139
16		H	−87·89239	−·293954	−·2057	−·0903	−·4681
17		M	228·62199	·764622	·3544	·2349	·5342
18		S	−136·18817	−·455479	−·2744	−·1399	−·5381
19		F/C	27·49394	·091953	·1363	·0283	·6591
20		I	−318·78852	−1·066182	−·1190	−·3276	−·0432
21	Fd	Ff	28·24565	·094467	0·943	·0257	·3460
22		Bg	96·78476	·323693	·1179	·0882	·1576
23		H	9·55097	·031943	·0211	·0087	·0509
24		M	−6·32285	−·021147	−·0092	−·0058	−·0148
25		S	−3·22799	−·010796	−·0061	−·0029	−·0127
26		F/C	7·48601	·025037	·0349	·0068	·1795
27		I	−89·05778	−·297850	−·0313	−·0811	−·0121
28	Ff	Bg	80·35837	·268757	·3586	·9843	·1308
29		S	19·69154	·065858	·1369	·2412	·0778
30		F/C	3·45187	·011545	·0590	·0423	·0827
31		I	37·48569	·125370	·0483	·4592	·0051
32	Bg	Bl	−346·76270	−1·159741	−·4763	−·5646	−·4019
33		H	16·56628	·055406	·0488	·0270	·0882
34		M	−114·53948	−·383075	−·2235	−·1865	−·2676
35		S	96·97327	·324325	·2460	·1579	·3832
36		F/C	16·75187	·056026	·1045	·0273	·4016
37		I	29·62734	·099088	·0139	·0482	·0040
38	H	M	−184·93004	−·618495	−·6529	−·9849	−·4321
39		S	−6·22255	−·020811	−·0286	−·0331	−·0246
40	M	S	−246·41905	−·824144	−·7490	−·5758	−·9737
41	S	F/C	−·92030	−·003078	−·0089	−·0036	−·0221
42		I	−6·84051	−·022878	−·0050	−·0270	−·0009
43	F/C	I	−242·71298	−·811749	−·4371	−5·8189	−·0329
44	F	G	54336·52194	181·72749	·4186	·0578	3·0323

The standard errors and variances used in calculating these coefficients are included in Appendix Table III.

[1] r necessary for significance, with P of ·05, = ·113; P of ·01, = ·148

Key:— C = Carcass score; L = Length of side; Fa = Av. depth of fat; Fd = Max. difference of fat; Ff = Firmness of fat; Bg = " Belly grade; Bl = Min. belly thickness; H = Per cent ham; M = Per cent middle; S = Per cent shoulder; F/C = Feed/carcass gain ratio; I = Maturity index; F = Feed; G = Gain

1. Carcass Score

Upon investigating the relationship of certain characters, other than those which are used directly in making up the score, with the carcass score, it is noted that firmness of fat is significantly correlated with carcass score. Although this item is not used directly in the construction of the score it is later in Table 6 shown to be related to both belly grade and average depth of back fat and its association with the score is probably due to, and influenced by, the relationship of these characters with the score.

In this study the feed/carcass gain ratio and the maturity index, (2) and (3), apparently have no effect on carcass score. These data would indicate that a selection for economical feeders would not in any way affect the excellence of the carcasses.

2. Length of Side

Of particular interest to this work were the findings of Sinclair and Murray (26), who also studied certain Advanced Registry data and report that no simple correlations were evident between the length of carcass and depth of fat, belly thickness, and/or the shoulder and ham percentages. These results were substantiated in this study, and in addition to per cent shoulder and ham, the per cent middle apparently bears no relation to the length (9). In this latter case, it would seem that a correlation might exist between per cent middle and length of side, and indeed a relationship was indicated at some stations (the corrected sums of cross-products were compiled by stations), but not at others. This investigation shows no apparent association between length of side and belly grade (7), nor any simple correlation of uniformity of fat (5), or the feed/carcass gain ratio (11) with length.

There is noted a correlation between length of carcass and firmness of fat (6), and maturity index (12). While the indication is that the longer the carcass, the softer the fat, and the higher the maturity index, the precaution of interpreting cause and effect should again be cited. Neither of these correlations exceed the 1 per cent point required for significance, nor is it certain that other factors have not influenced this result. However, Scott (24), and Callow and Davidson (4) have also shown that the long type of pig had a faster growth rate than the short type, and although the two characters showing an association with length (firmness of fat and maturity index) show no relationship between themselves in this study (31), Scott (25) further reports that maturity is a factor of importance in connection with soft pork. Scott had previously stated (23), that the long-bodied hog required a much thicker covering of fat, than the short-bodied one, before the fat became hard. Bull, Olsen, Hunt, and Carroll (1) report that the intermediate type hog, (medium length) tended to be the firmest. It is to be remembered that the type of hogs used in the United States in these cited experiments was quite different to that involved in this study, but, nevertheless, the results are similar to those in this investigation.

3. Average Depth of Fat

The simple correlations indicate that as the depth of fat increases, the per cent middle (17) and the amount of feed per pound carcass gain also increase (19), and the firmness of fat (14) and belly grade (15) improve, while the per cent ham (16) and shoulder (18), and the maturity index (20) decrease. These results are quite analogous with those reported by Scott (25) in this connection. He states that as the depth of fat increases the percentages of the lean cuts in the carcass (loins and hams) decrease, while those of the fat cuts (back fat and bacon sides) increase. When the depth of fat covering increases, he further reports, the percentage of fat in the fat tissue increases, and the percentages of moisture and of protein decrease; these changes are accompanied by a change in the composition of the fat tissue, which results in a lowering of the refractive index (hardening of the fat) and an improvement in the quality of the meat.

4. Uniformity of Fat

Uniformity of fat is correlated with belly grade (22). The association ($r = \cdot1179$), however, is not highly significant but does suggest that the more uniform the fat the better the grade of belly. Uniformity does not appear to be related to any of the other characters with which its association was examined. Though the relationship between the uniformity of fat and its firmness (21) is not significant, statistically, there is some indication that the softer fat is also less uniform.

5. Firmness of Fat

The correlation between firmness of fat and belly grade (28) points out that, as the fat becomes firmer the belly grade also improves. From the regression it is indicated that with an improvement of one unit or grade of firmness, from fairly firm to firm, for instance, there might also be expected an improvement in belly grade of ·98, or almost a full grade, such as, from good to good plus.

6. Belly Grade

As the grade of belly improved in these data the minimum thickness of belly and the per cent middle increased, while the per cent shoulder decreased (32), (34), (35). There is some indication, though not statistically significant, that the more economical feeders, as represented by the feed/carcass gain ratio, also had the better bellies (36).

7. Percentage Cuts

The simple correlations show the percentage cuts to bear certain specific relations to one another. As the percentage middle increases both the percentage ham (38) and shoulder (40) decrease, with no evident association between ham and shoulder (39). In the regressions, with an increase of one unit or per cent in ham or shoulder, there was a corresponding decrease in middle of about one unit.

8. Feed Utilization

The rate of maturity and economy of feed consumption are in these data correlated to a highly significant degree (43), r being $-\cdot4371$. That is to say, the faster the pigs reached maturity, as indicated by a higher maturity index, the less feed was required per pound of carcass gain. The regression shows that with an increase of one pound of feed required per pound carcass gain, there is also an increase of about twelve days in the time taken by a pig to reach 200 pounds live weight (150 pounds cold carcass weight). In terms of maturity index this represents a decrease of about six units.

9. Feed and Gain

In this study increased live weight gain was associated with increased feed consumption per pig, as shown by the correlation, $r = \cdot4186$ (44). The regression indicates that an increase of one pound of gain is combined with an increase of 3·03 pounds of feed. While this is, in a sense, a feed/gain ratio, it is somewhat lower than the calculated average feed/gain ratio, because it considers the fact that all feed is not used for gain, a portion being used for maintenance.

D. PARTIAL REGRESSION STUDIES

1. The relative influence of factors affecting the carcass score and the average depth of back fat

By the method of partial regression, following the procedure outlined by Wallace and Snedecor (28), the relative weight of certain factors affecting carcass score, and of the percentage cuts on average depth of fat, were studied. The results of the two groups investigated are presented in Table 7.

TABLE 7—RELATIVE EFFECTS OF INDEPENDENT VARIABLES ON CARCASS SCORE AND DEPTH OF FAT

Group	Variables		Simple Reg. Coef. (b'') [1]	Partial [2] Reg. Coef. (b) [3]	Standard [4] Part. Reg. Coef. (β)	Multiple [4] Correl. Coef. (R)	Standard Error of Reg. Coef.	"t" [5]
	Dep.	Indep.						
I.....	C	F/C	−·1489	−·6031	−·0303	·2567	·0628	·4825
		I	·1050	·1030	·0687	.....	·0628	1·0939
		Ff	−3·4457	3·4615	−·2432	.....	·0565	4·3044*
II.....	Fa	H	−·4681	−·9485	−·4164	·3457	·2865	1·4559
		M	·5342	−·4531	−·3004	.....	·4314	·6963
		S	−·5381	−1·0026	−·5113	.....	·3269	1·5641

[1] See Table 7, page 00; [2] See Fisher, page 132; [3] $b=\frac{r}{y}$ [4] See Wallace and Snedecor, pages 35, 44, 47;

[5] "t" for P of ·05=1·968; P. of ·01=2·592; N=300.
*=significant.

Group I.—In Group I, with carcass score (C) the dependent variable, it is apparent that of the three independent variables firmness of fat is the only one significantly associated with variations in the score. At the same time, and although the fact that firmness of fat is given cognizance in the carcass score through its relationship with the belly grade and depth of back fat is again cited, the necessity for firm carcasses is emphasized.

Group II.—In view of the findings of Hankins and Ellis (18) that the average depth of fat is of very definite value for estimating the percentage fatness of the edible portion of the carcass, together with the indication in this study that average depth of fat and the percentage cuts, as taken in the Advanced Registry, are correlated, it was thought that an examination of the relative effect of the three percentages (ham, middle, and shoulder) on the average depth of fat would prove of interest. However, while the simple correlation coefficients between the percentage cuts and the average depth of fat are highly significant, the partial regressions, as shown by the "t" values, are not. It would seem that some inter-relationship of the percentage cuts, or the association of the percentage cuts with other factors, such as belly grade, minimizes their individual effect on the depth of fat when put into a partial regression.

The reduction of the standard deviations associated with the carcass score and the average depth of fat by a further step with the multiple correlation coefficients, was investigated. The proportion of the variability, due to the measurable factors, is expressed by the square of the multiple correlation coefficient (R^2). The value of R^2 in Group I is ·2567 and ·3457 in Group II. Correspondingly, the proportion of the total variance not accounted for is expressed as $(1 - R^2)$.

As may be expected from the small values of R^2 and the loss of degrees of freedom through the regression, the reduction of the standard deviations associated with the carcass score and the average depth of fat was not great.

E. FREQUENCY DISTRIBUTIONS OF CARCASS SCORE DEDUCTIONS

The Advanced Registry carcass score, constructed as is shown in Chart III, is not only a valuable index as to the relative capacity of sows to produce pigs of particular excellence, but the detail of the scores allotted the various characters shows wherein a sow is strong and, also, where improvement in the strain is needed. A sample of the detailed carcass score of a sow tested under the Advanced Registry might read: Length, 23; thickness of back

fat, 10; evenness of back fat, 8; ham, 8; middle, 6; shoulder, 5; quality of belly, 17; deductions for over-weight carcasses, 2; the sow's total carcass score, 75. While the above sow would qualify with the score obtained, there are certain interpretations to the individual scores of the different divisions of interest. The 23 points obtained for length show that one pig measured between 30 and 30½ inches, while the other three were above the latter measurement which is the minimum length required. In the fat characteristics one pig either exceeded the maximum back fat of two inches or measured less

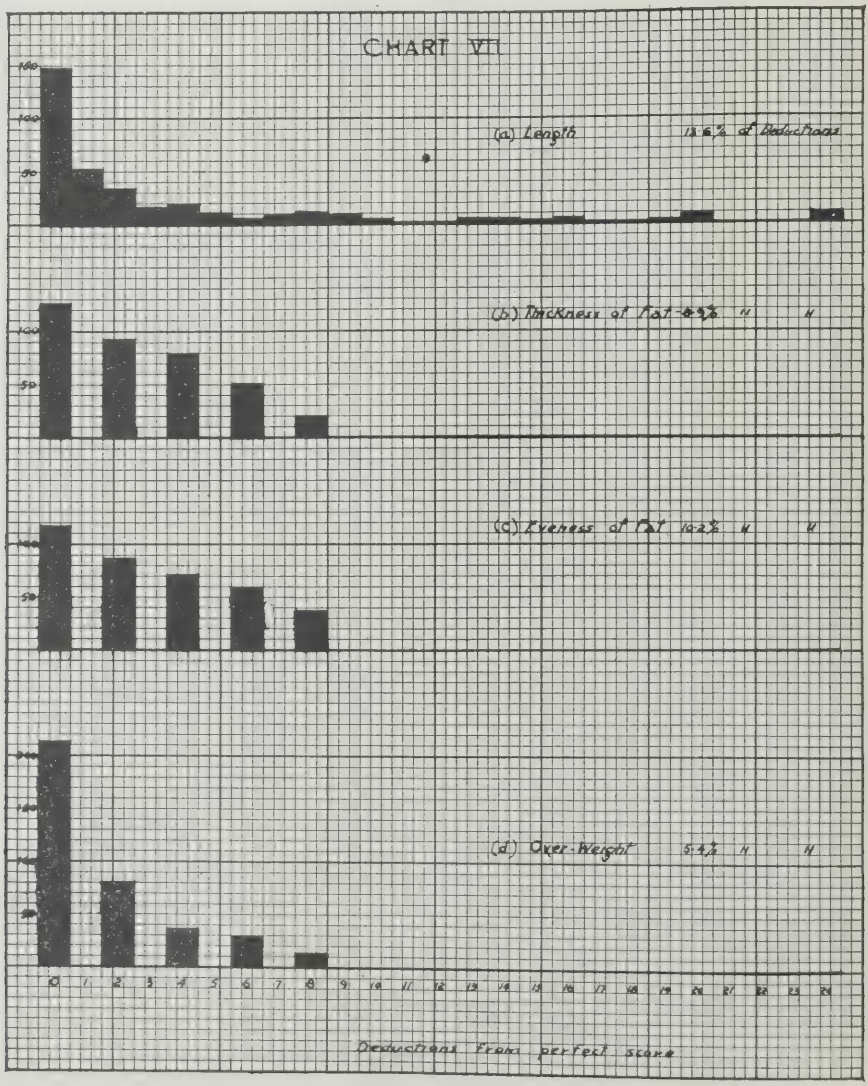

CHART VII. Deductions from carcass score.

than the minmum of one inch tolerated. Two pigs had too wide a spread between their minimum and maximum back fat measurements for which four points were deducted from the perfect score for evenness or uniformity of fat. The scores obtained for balance of side can easily be reconverted to percentages, and the four pigs of this sow averaged 24 per cent ham, 47 per cent middle, and 29 per cent shoulder. The shoulder obviously is much above the balance desired. As eight points were deducted from the optimum

score for belly quality, the average of the pigs was "good," although all four carcasses may not have been thus graded. One pig could have been "excellent," two "good," and one "fair" with the same deduction of eight points from the maximum allowed for quality of belly. The two points deducted from the above sample score, due to overweight carcasses, indicate that one of the carcasses exceeded the 160 pound limit. So it is seen that the carcass score gives an excellent picture of the type and quality of pigs produced by a sow.

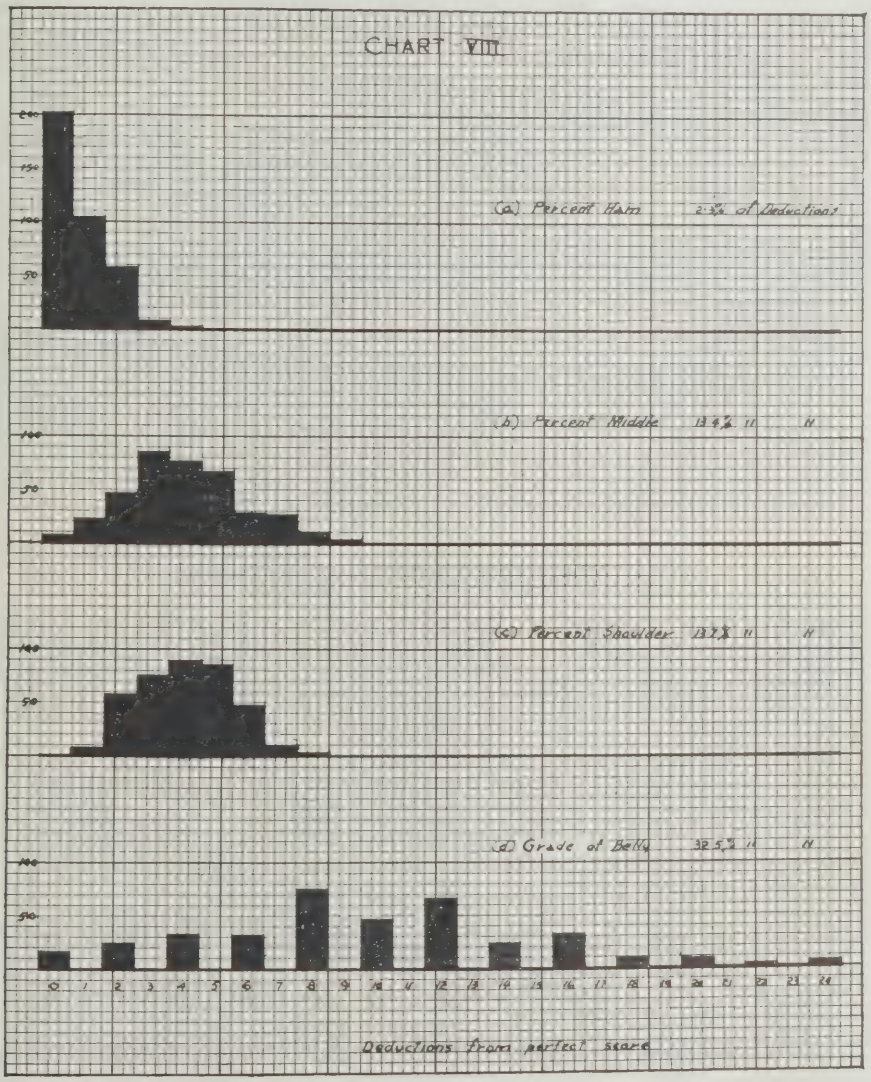

CHART VIII. Deductions from carcass score.

The scores of the 370 sows included in this study were examined to ascertain the distributions of the deductions in each division of the score, and where the Experimental Farms' pigs did not meet the specifications required. In order that all divisions of the score should be comparable, the scores obtained were plotted as deductions from the optimum scores. Charts VII and VIII are frequency distributions of the deductions made in the 370 carcass scores. By following this procedure it was possible to accumulate the

deductions and arrive at a general mean of the 370 scores. This mean served only as a check on the scoring, and it was identical with the general mean previously calculated. The deductions in each division of the score are also expressed as a percentage of the total deductions.

While the charts showing the distributions are in many ways self-explanatory, certain observations are of interest. In particular, the percentages of the total deductions shown with each character are significant. Although the deductions for length were widely spread, the relative weight of length in depressing the score was only 13·6 per cent. With thickness and evenness of fat it will be noted there were a greater number of the larger deductions for lack of evenness. This is borne out in that 10·2 per cent of the total deductions was due to lack of uniformity as compared to 8·9 per cent due to the thickness of fat not meeting the specifications.

The distribution of the deductions for over-weight carcasses shown in Chart VII (*d*) would indicate the necessity of marketing pigs at the required weight. A check on the progress of the pigs and the approximate dressing percentage generally obtained with the strain of pigs would insure against having carcasses weighing over 160 pounds, and thus might be expected to materially lower the observed 5·4 per cent effect. With an average dressing percentage of 75 per cent, marketing at live weights from 200 to 215 pounds is recommended.

The relative effect of the balance of side on the carcass score substantiates the previous intimation that the average per cent shoulder is much higher than that desired. The percentage of ham in these hogs seems good. Although the yearly averages indicate that the belly grade of the pigs tested by the Dominion Experimental Farms is improving, the distribution of the deductions and the percentage of the total deductions, which is shown as 32·5 per cent, suggest that further improvement is needed in this important character.

IV. SUMMARY AND CONCLUSIONS

During the six-year period, 1929-34, 370 litters of pigs (representing 1,480 individuals) were subjected by the Dominion Experimental Farms to test under the Canadian Advanced Registry Policy for Swine. A study of the data accumulated in the course of these tests forms the basis of this report, and the results obtained are summarized as follows:—

The type and usefulness of the Experimental Farms' sows for bacon production, as measured by progeny tests under the Advanced Registry, have improved steadily over the six-year period, 1929-34. This has been indicated particularly by the general improvement in the average carcass score, rate of maturity, length of side, uniformity and firmness of fat, and the thickness and quality of belly, of the litters recorded.

In respect to balance of carcass, the improvement toward the desired proportions of 25 per cent ham, 50 per cent middle, and 25 per cent shoulder has not been marked. The percentage middle has tended to increase, but, at the same time, the percentage shoulder has remained constantly too high, averaging about 29 per cent. The percentage ham has decreased to about the same degree the middle increased; the ham, nevertheless, approaches the desired standard.

The variability in most of the characters, due to different stations and years, was seen to be significant. The average coefficients of variability taking all the characters together were: between stations, 11·0 per cent; between years, 5·1 per cent; and, between sows, 9·3 per cent. The station and year variability is no doubt a reflection of the wide differences in geographic location, strains of pigs, management and feeding, and the improvement from year to year. It is indicated that differences due to environment should be considered in selection, or in comparing sows.

In simple correlation, the amount of feed required for a pound of carcass gain (feed carcass gain ratio) seemed in no way to affect the final score or to estimate the excellence of the carcasses of a litter. This would imply that selection for excellence would not affect the ability of pigs to utilize feed economically. However, the maturity index was correlated with the feed/carcass gain ratio, indicating that as the rate of maturity increased, the amount of feed per pound carcass gain decreased.

As the average depth of fat increased, the percentage middle and feed/carcass gain ratio increased, and firmness of fat and belly grade improved, while the percentage ham, percentage shoulder, and the maturity index decreased. The uniformity of the fat did not seem to be affected by its average depth or the length of carcass.

The grade of belly improved with an improvement in firmness of fat, increased minimum thickness of belly and percentage middle, and decreased percentage shoulder. In the percentage carcass cuts, as the percentage middle increased, the percentage ham and shoulder decreased. The percentage ham was not correlated with shoulder.

From a study of the relative weight or effect of three factors which are not directly considered in estimating the carcass score, viz., feed/carcass gain ratio, maturity index, and firmness of fat, on the carcass score, it was shown that only firmness of fat was significant. Its association was taken to be due to the relationship between firmness and the belly grade and depth of back fat.

In fixing the minimum carcass score acceptable for Advanced Registration, the use of the coefficient of variability of all sows tested under standard conditions would appear to be highly desirable from the standpoint of selecting sows of exceptional excellence.

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APPENDIX TABLES

APPENDIX TABLE I—DISTRIBUTION OF TESTED LITTERS[1]—BY STATIONS—BY YEARS

Station	1929	1930	1931	1932	1933	1934	Total
Ottawa	9	5	2	2	4	1	23
Nappan	5	9	5	5	3	2	29
Kentville	1	2	–	4	–	–	7
Fredericton	6	6	4	3	2	–	21
Charlottetown	–	–	–	1	–	–	1
Ste. Anne	7	7	–	7	3	6	30
Lennoxville	3	–	3	3	–	–	9
Cap Rouge	6	4	6	–	–	–	16
La Ferme	4	–	–	–	–	–	4
Kapuskasing	4	–	–	–	–	–	4
Brandon	7	6	3	3	–	–	19
Indian Head	3	–	4	1	–	8	16
Rosthern	14	10	11	–	–	–	35
Scott	5	6	4	5	6	–	26
Swift Current	–	2	–	–	–	–	2
Lacombe	15	15	12	10	7	7	66
Lethbridge	9	18	4	1	–	3	35
Agassiz	6	2	2	2	3	3	18
Summerland	–	–	–	2	4	3	9
Year Totals	104	92	60	49	32	33	
Grand Total							370

[1] Litter=4 pigs.

APPENDIX TABLE II.—STATION AVERAGES (AV. OF 6-YEAR PERIOD)

Station	No. of sows recorded	A. R. Scores		Age and Weights			Gain and Feed					Length and Depth			Fat			Belly		Percentage Cuts		
		Carcass score	Maturity index	Age at slaughter	Initial weight	Cold carcass weight	Gain per pig	Daily gain	Feed per pig	Feed/gain ratio	Feed/carcass gain ratio	Length of side	Depth of flank	Depth of heart	Av. depth of fat	Max. diff. of back fat	Firmness of fat (*)	Min. thickness of belly	Grade of belly (*)	% ham	% middle	% shoulder
				days	lb.	lb.	lb.	lb.	lb.			in.	in.	in.	in.	in.		in.				
Ottawa	23	71·7	105·8	194·3	37·1	155·9	173·1	1·33	520·0	3·01	3·95	30·92	11·70	13·63	1·33	·844	2·16	·842	3·25	25·5	45·4	29·1
Nappan	29	66·8	105·3	193·0	25·6	152·9	185·9	1·33	677·9	3·64	4·96	30·25	11·69	13·70	1·40	·875	1·40	·647	4·53	24·5	46·8	28·7
Kentville	7	66·9	107·3	187·4	23·0	152·1	186·0	1·30	574·0	3·24	4·20	31·07	11·58	13·54	1·36	·881	1·39	·568	5·18	24·5	46·1	29·4
Fredericton	21	74·9	113·7	181·5	25·1	158·9	198·1	1·43	718·8	3·63	5·04	30·92	11·69	13·81	1·51	·900	1·39	7·17	2·68	23·9	46·9	29·1
Charlottetown	1	70·0	117·0	181·0	25·6	165·0	186·0	1·42	856·0	4·59	5·76	31·75	11·56	13·37	1·50	·813	1·00	1·063	4·00	23·4	49·8	26·8
Ste Anne de la Pocatiere	30	67·8	106·5	190·8	31·6	153·3	179·2	1·39	596·6	3·33	4·51	30·09	12·81	13·78	1·43	·850	2·27	·886	4·69	25·1	46·6	28·3
Lennoxville	9	63·2	108·1	190·7	34·5	158·4	178·7	1·29	642·4	3·59	4·72	30·68	12·45	13·88	1·44	1·113	3·03	·871	3·75	24·7	46·6	28·6
Cap Rouge	16	51·0	90·9	217·7	27·7	143·3	177·4	1·11	673·4	3·80	5·38	29·08	13·16	13·94	1·33	·900	2·84	·679	6·66	26·0	44·6	29·4
La Ferme	4	51·0	98·7	199·7	27·7	145·5	183·7	1·33	690·5	3·76	5·42	29·75	12·23	13·37	1·18	·706	3·37	·696	7·44	26·7	44·1	29·2
Kapuskasing	4	57·7	96·0	209·0	32·2	149·7	175·0	1·16	581·5	3·34	4·51	29·42	12·73	13·42	1·37	·963	1·94	·727	4·44	26·8	44·9	28·3
Brandon	19	77·4	103·5	195·4	25·0	151·7	188·1	1·29	726·8	3·87	5·35	30·39	12·73	13·73	1·48	·694	2·68	·966	4·00	26·5	45·8	27·7
Indian Head	16	70·3	100·4	200·8	27·7	150·6	183·1	1·23	678·4	3·72	5·12	30·99	12·17	13·66	1·39	·750	3·31	·861	5·55	24·3	45·5	30·2
Rosthern	35	69·8	104·4	192·8	32·5	151·3	177·4	1·33	654·5	3·68	5·03	30·44	13·28	13·74	1·39	·731	3·44	·982	5·59	25·1	45·9	29·0
Scott	26	72·6	111·0	182·3	28·2	151·6	182·8	1·54	713·5	3·91	5·38	30·76	11·23	13·49	1·39	·644	2·09	·719	5·83	25·2	45·3	29·4
Swift Current	2	76·5	99·5	201·0	31·6	151·0	173·0	0·97	851·5	4·91	6·53	29·87	13·50	14·16	1·46	·875	4·00	1·031	4·37	27·5	44·8	27·7
Lacombe	66	74·2	106·2	192·0	32·8	154·3	173·3	1·29	753·1	4·35	5·67	30·77	11·36	13·74	1·46	·706	1·94	·854	4·31	24·5	46·7	28·8
Lethbridge	35	72·5	97·8	211·1	29·9	157·6	185·6	1·25	872·3	4·70	6·31	30·66	11·05	13·66	1·54	·650	2·09	·851	4·84	25·6	44·8	29·5
Agassiz	18	77·7	107·2	189·3	26·0	153·5	177·4	1·36	601·8	3·44	4·46	30·93	11·49	13·28	1·43	·737	1·92	·772	3·13	24·5	47·0	28·5
Summerland	9	75·8	112·0	181·3	32·5	153·3	169·9	1·36	463·3	2·73	3·52	30·27	11·16	13·33	1·33	·694	1·25	·989	2·58	23·2	46·2	30·6
Mean of 370 litters	.....	70·66	104·9	194·2	29·96	153·4	180·4	1·32	687·0	3·81	5·13	30·54	11·94	13·68	1·43	·772	2·23	·826	4·55	25·0	46·03	28·97

* Coded, see Table 2.

APPENDIX TABLE III.—VARIANCE OR M.S. OF CHARACTERS

Character	Stations		Years		Sow-groups	
Degrees of Freedom	Between(*) 18	Within 351	Between (*) 5	Within 364	Between 70	Within 299
Advanced Registry Scores—						
Carcass score	732·2045	97·9423	1462·6410	110·5611	442·6679	55·4203
Maturity index	522·4289	56·3431	1359·8512	61·4860	311·5099	24·6638
Age and weights—						
Age at slaughter	1724·0921	230·6582	5108·1406	237·5110	1136·8038	108·4228
Initial weight	264·7775	42·0357	674·8094	44·3584	204·4034	17·4324
Cold carcass weight	232·8877	37·1248	269·5252	43·6131	139·0304	25·0524
Gain and feed—						
Gain per pig	921·0900	90·5618	976·9992	119·4555	434·9677	59·9299
Daily gain	·1772	·0198	·2998	·0237	·1081	·0086
Feed per pig	183641·3270	5664·2185	47391·4299	13892·1083	62196·5762	3143·5594
Feed/car. gain ratio	9·0085	·2815	·9989†	·7032	3·1320	·1395
Carcass measurements—						
Length—						
Length of side	1045·0622	250·6090	7195·1200	194·5035	1097·3080	100·2118
Fat—						
Av. depth of fat	22·9288	4·4157	27·4421	5·0149	14·1362	3·2545
Max. diff. fat	57·3380	4·2250	15·6708‡	6·6943	20·2518	3·6703
Firmness of fat	8·6826	·4401	6·4562	·7651	3·2732	·2730
Belly—						
Min. thick. of belly	60·7917	5·0171	64·4299	6·9591	28·4621	2·8860
Grade of belly	22·5635	2·6521	17·3702	3·4346	10·3265	2·0541
Percentage cuts—						
Per cent ham	11·5190	2·1573	111·1618	1·1230	11·0973	·6280
Per cent middle	13·3516	2·6416	48·8335	2·5367	10·5651	1·4313
Per cent shoulder	7·5293	1·5699	14·4564	1·6875	6·1924	·8464

(*) Upon applying the "z" test, in all cases except two the variance due to "between stations" and that due to "between years" is significantly higher, with P= ·01, than that due to "within stations" and "within years", respectively.

(†) As the "z" value required for significance with P= ·05, N^1=5 and N^2=364 is ·3974, and "z" in this case is—·1685, the variance in the feed/carcass gain ratio due to between years is not significantly higher than that within years.

‡ Significant with P=·05; z=·4252; "z" necessary with P=·01=·5522.

APPENDIX TABLE IV—STANDARD DEVIATIONS AND VARIANCE OF CHARACTERS(*)

Character	Symbol	M.S.	S.D.	Gen. Mean	C.V. %
Carcass Score	C	55·4203	7·444	70·6567	10·53
Length	L	100·2118	10·01	488·6189	2·05
Average Depth Fat	Fa	3·254536	1·804	22·8305	7·90
Maximum Difference Fat	Fd	3·670356	1·916	12·3489	15·5
Firmness of Fat	Ff	·273040	·523	2·2324	23·43
Minimum Belly	Bl	2·885993	1·699	13·2081	12·86
Belly Grade	Bg	2·054148	1·433	4·5541	31·47
Per cent Ham	H	·627987	·792	25·0065	3·17
Per cent Middle	M	1·431325	1·196	46·0278	2·60
Per cent Shoulder	S	·846427	·920	28·9716	3·17
Feed/Carcass gain ratio	F/C	·139503	·374	5·1323	7·29
Maturity Index	I	24·6638	4·966	104·9297	4·73
Feed	F	3143·5594	56·067	687·0189	8·16
Gain	G	59·929979	7·741	180·4000	4·29

* Based on "Between sow" portion of total variance.

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